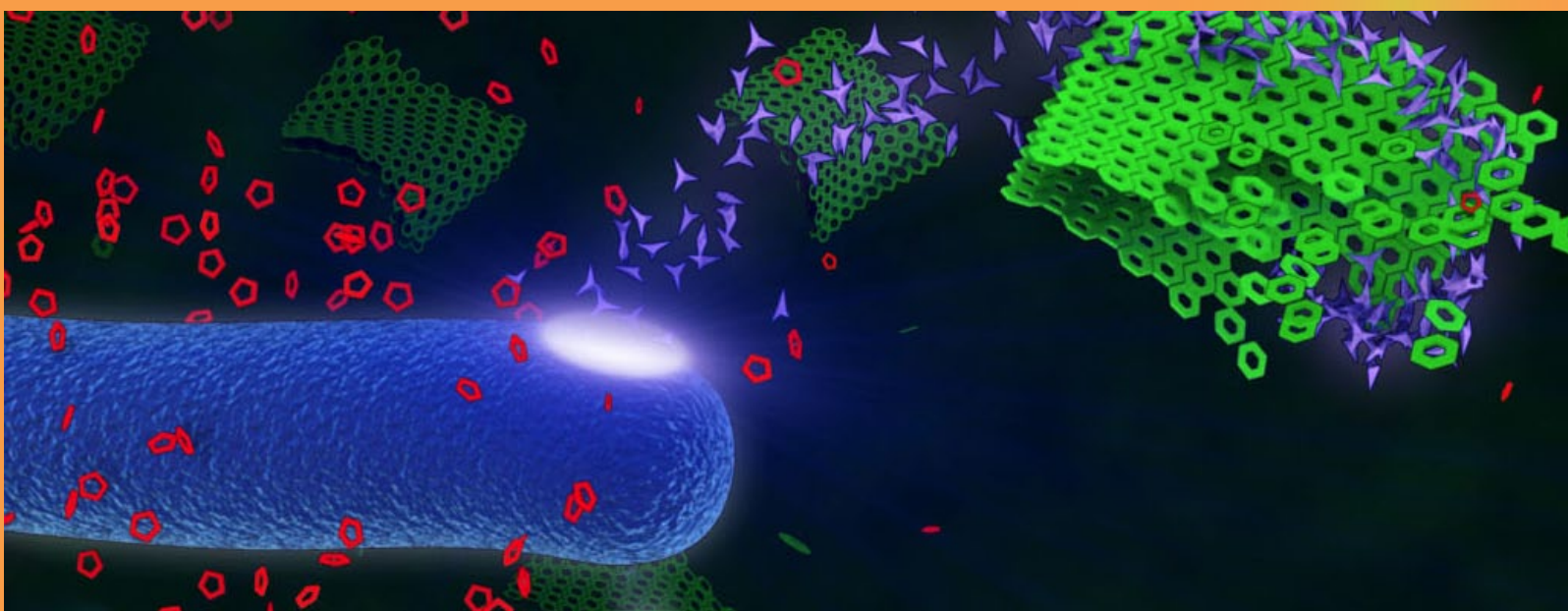


Science and Technology UPDATE

April/May 2012



**A bulletin of achievements
at Lawrence Livermore National Laboratory**



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EARLY-CAREER SCIENTISTS WIN \$10 MILLION FROM OFFICE OF SCIENCE

Four LLNL scientists were among 68 awardees chosen from 850 applicants for the Office of Science 2012 Early Career Research Program. The four will collect a total of \$10 million in new research funding for the following projects: Céline Bonfils, “Detection and Attribution of Regional Climate Change with a Focus on the Precursors of Droughts”; Gianpaolo Carosi, “Searching for Dark Matter Axions with New High-Frequency Tunable Microwave Cavities”; Andreas J. Kemp, “Large-Scale Modeling of Intense Short-Pulse Laser Interaction for HEDLP”; and Jaime Marian, “Computational Modeling and Design of Radiation-Tolerant Materials for Fusion.”

The Early Career Research Program, now in its third year, is open to researchers at universities and

DOE national laboratories. The **competition** supports the development of individual research programs of outstanding scientists early in their careers and stimulates research careers in the disciplines supported by the DOE Office of Science. Of this year’s 68 awards, 24 went to staff at DOE national laboratories and 44 to university researchers. Relative to other DOE labs, Livermore tied with Oak Ridge and Argonne, which also received four awards each. Fermilab and LBNL both received three awards, and LANL received two. Four other laboratories received one award each. Each award provides \$500,000 per year for 5 years. The photo shows, left to right, Andreas, Céline, Gianpaolo, and Jaime.



About the Cover

Research on a rainforest soil bacterium has revealed a possible path to the more efficient production of biofuels by revealing how the organism molecularly tolerates ionic liquids used in feedstock pretreatment—liquids that are often toxic to such microorganisms. See “Bacterially Boosting the Efficiency of Biofuel Production,” on pg. 6.

DTRA AWARD FOR NUCLEAR FORENSICS WORK

For the second straight quarter, a Laboratory employee has received an award from the Defense Threat Reduction Agency (DTRA) for work in post-



detonation nuclear forensics. The most recent winner is Lab physicist Roger White, who was named top contributor for the second quarter (January–March) of fiscal year 2012 for integrating a multilab effort to develop a research event to help develop improved diagnostics of prompt signals. Funded by DTRA, Roger's team is developing new methods for better forensic analysis of the speed-of-light signals from a nuclear explosion, with the goal of speeding and improving post-event forensics for attribution. Roger's team includes engineer Craig Halvorson, physicists Brad Sleaford and Britton Chang, radiochemists Yves Dardenne and Winnie Parker, code physicist Teresa Bailey, computer scientist Steve Anderson, and nuclear engineer Doug Vogt.

ENGINEER NAMED VICE-CHAIR OF ANS FUSION ENERGY DIVISION

LLNL nuclear engineer Susana Reyes has been elected vice-chair of the American Nuclear Society (ANS) Fusion Energy Division and will serve as chair in 2013. Since joining the Laboratory to work on the safety analysis of inertial fusion energy power plant designs, Susana has worked in a variety of fusion research projects, such as the ITER magnetic fusion facility under construction in Cadarache, France, where she was in charge of coordinating safety analyses in preparation for ITER licensing. She has also been strongly involved in neutronics and materials damage simulations at LLNL in support of high-energy accelerators and NIF. She is currently the **leader** of LIFE Licensing and Tritium Systems.

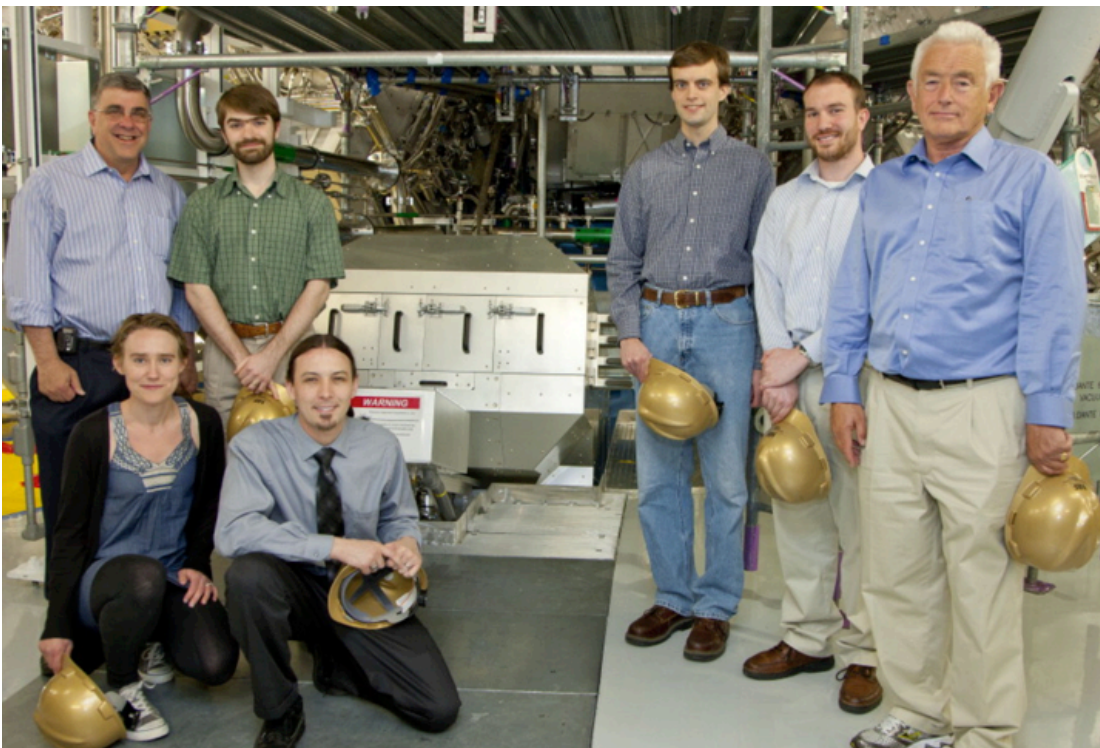


DNDO AWARD TO SCINTILLATOR TEAM

The Domestic Nuclear Detection Office (DNDO) has chosen Nerine Cherepy, Steve Payne, and the rest of Livermore's Scintillator Discovery Team for an award for superior performance in support of the DNDO mission. The award recognizes the team's development of new high-performance scintillators. The honors were presented on May 14 at the IEEE 2012 Symposium on Radiation Measurements and Applications (**SORMA**).

FIRST GRADUATING CLASS OF NIF PH.D. PROGRAM MEASURES HOHLRAUM-PRODUCED FAST IONS

The first measurements of fast ions produced in indirect-drive hohlraum experiments and their relationship to hot electrons are described by MIT and LLNL researchers in an article **published** in *Physics of Plasmas*. In experiments at the OMEGA laser facility at the University of Rochester, the researchers observed protons in two energy regimes associated with different fast-ion production mechanisms. In both cases, runaway electrons set up a strong electrostatic field that accelerates the measured ions. Fast protons with energies from 300,000 to 800,000 electron volts were observed in both vacuum- and gas-filled hohlraums. Lead author Alex Zylstra, of MIT, was joined by fellow Ph.D. students Mike Rosenberg and Hans Rinderknecht, thesis advisor Richard Petrasso and other MIT colleagues, and LLNL's Nobuhiko Izumi, Peter Amendt, Nino Landen, and Jeff Koch. The students are the first to participate in a new NIF Ph.D. thesis program. Pictured with NIF PAD Ed Moses and Joe Kilkenny are, left to right, MIT's Maria Gatu-Johnson, Hans, Dan Casey, Alex, and Mike.



OPTICAL SOCIETY NAMES SENIOR MEMBER

Lynn Seppala has been named a senior member of the Optical Society of America (OSA). Lynn, a senior optical designer supporting NIF, received this elevated status in recognition of his contributions to optics research, which also includes being a key contributor to the optical design of the 8.4-meter-diameter Large Synoptic Survey Telescope (LSST). When it becomes operational in 2020 on Cerro Pachón in the Chilean mountains, LSST will be the world's largest light-gathering astronomical telescope. Lynn's involvement in the OSA includes chairing the Optical Design Technical Group from 1990 to 1992.



The OSA consists of more than 17,000 members from 175 countries, working to promote the science of light and the advanced technologies made possible by optics and photonics.

LAB'S INTEGRAL ROLE IN 14-NATION MISSILE DEFENSE EXERCISE

Two hundred participants from 14 nations, along with observers from NATO and other organizations, spent four days planning political, military, and civil defense responses to scenarios involving mock missile launches from fictitious countries. Much of the background information on which the unclassified decision-making was based came from ballistic missile defense work done at LLNL.

Coordinated by the Lab's Mike Tobin, who is assigned to the Pentagon's Missile Defense Agency,

dictions of nuclear yield and electromagnetic pulse (EMP), while Engineering's Mike Bland evaluated the EMP effects on civilian infrastructure.

LLNL HOLDS SCINTILLATOR NONPROPORTIONALITY PHYSICS CONFERENCE

LLNL, with the support of DOE and NNSA, held the Scintillator Nonproportionality Physics Conference on May 18 in Oakland, CA. The conference, organized by Livermore's Steve Payne, focused on the understanding of scintillator physics and the path



the Laboratory has been using its high-performance computing and its simulation resources—particularly the National Atmospheric Release Advisory Center (NARAC)—to contribute vital and detailed information necessary for quick and well-informed decision-making on such critical issues. At the exercise, named Nimble Titan 12, calculations by NARAC's Brenda Pobanz predicted the airborne dangers of nuclear fallout and the devastation of a ground nuclear detonation that could face populations in an impacted area. Global Security's Greg Dipeso assisted in pre-

forward to build a predictive capability for scintillator nonproportionality, which would ultimately enable the future development of breakthrough materials and extremely high-resolution radiation detectors. The meeting drew 57 attendees from seven countries, five U.S. agencies, 10 universities, four national laboratories, and six companies. Research by LLNL's Steve Payne, Nerine Cherepy, Daniel Aberg, Babak Sadigh, and Tayyab Suratwala was presented.

MECHANISM OF BLAST-INDUCED BRAIN TRAUMA UNCOVERED

A team including Livermore researchers has discovered a mechanism that could be the cause of traumatic brain injuries in soldiers impacted by explosions, such as those of improvised explosive devices (IEDs). The study, **published** in *Science Translational Medicine*, finds that the brain injuries result from head rotation or other motion caused by the blast wind. The research team created a blast neurotrauma mouse model that controlled head mo-



tion during blast exposure and found that when their heads were allowed to move, brain injuries in the mice were identical to the brain injuries caused by IEDs. However, when head motion was restrained, the mice exhibited no brain injuries or other neurological effects. The researchers also found that brain damage in blast-exposed veterans is similar to that suffered by football players who sustain multiple concussive head injuries—a significant finding because it demonstrates a common link between what has previously been believed to be two disparate injury mechanisms. Livermore's William Moss was **interviewed** by ABC affiliate KGO for a story on the breakthrough.

TWO LLNL PRESENTATIONS IN TOP 12 AT CARBON CAPTURE CONFERENCE

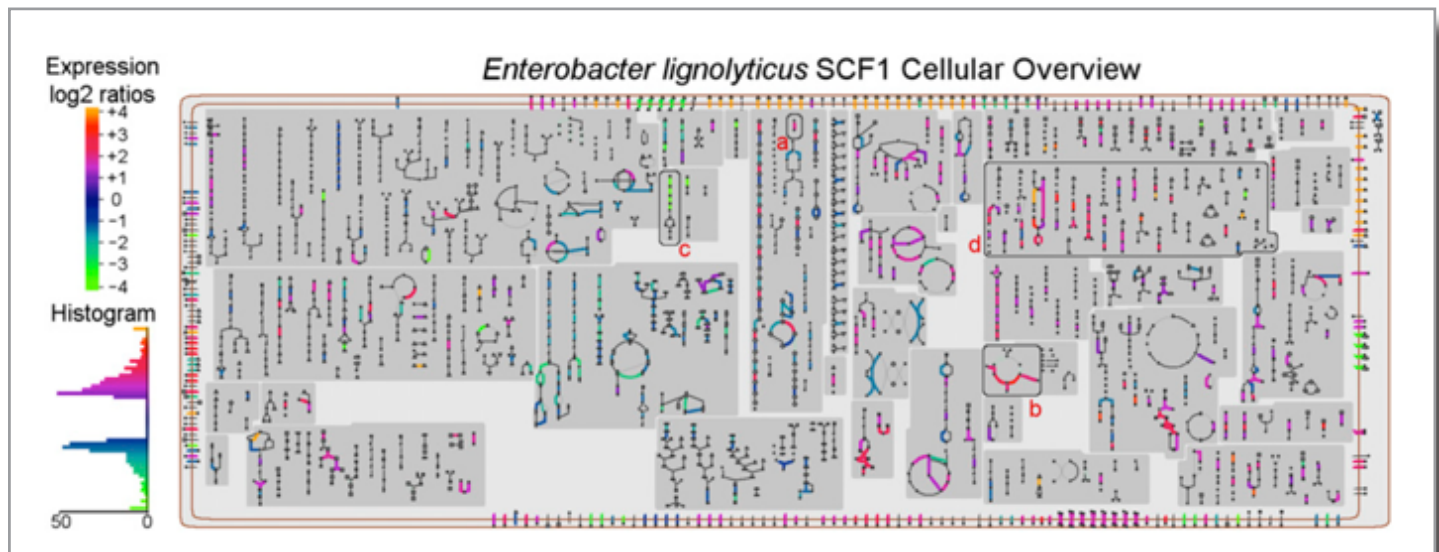
Two posters by LLNL researchers were voted by attendees as being among the top 12 presentations—out of a total of 290—at the 11th Annual Conference on Carbon Capture Utilization and Sequestration. The **conference** was held April 30–May 3 in Pittsburgh, PA. The first poster, entitled *Active CO₂ Reservoir Management: A Two-Stage Approach for Sustainable Geothermal Energy Production with Reduced Risk of Brine Leakage and Increased CO₂ Security*, by Tom Buscheck and Princeton University collaborators Tom Elliott, Karl Bandilla and Michael Celia, described a scheme to couple geologic CO₂ sequestration with geothermal energy production that provides technical and economic benefits to both operations. The second poster, *Assessing Hydraulic Fracturing of Porous*

Fractured Media Reservoirs, by LLNL researchers Souheil Ezzedine, Laura Chiaramonte, Walter McNab, Rick Ryerson, and Lee Glascoe, presented new results on ongoing work at LLNL to model the hydraulic fracturing of porous, prefractured media. Such systems are of great interest for both geothermal and unconventional natural gas production. Both teams have been invited to submit papers on their work to a special issue of *Greenhouse Gases: Science & Technology*.

BACTERIALLY BOOSTING THE EFFICIENCY OF BIOFUEL PRODUCTION

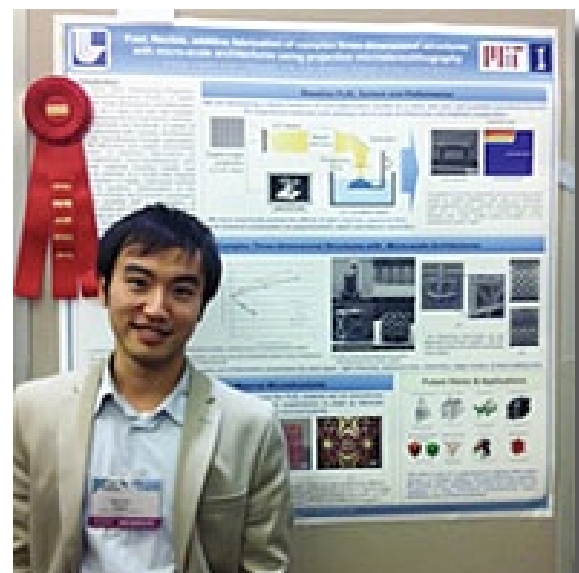
Research on *Enterobacter lignolyticus* strain SCF1, a bacterium found in rainforest soil, has revealed a possible path to the more efficient production of biofuels. The bacterium can degrade lignocellulose from plant biomass and, more importantly, has been found to grow even in the presence of the ionic liquids used to pretreat biofuel feedstock—liquids that are often toxic to other biofuel-producing microorganisms. A

team including Livermore's Jane Khudyakov, Patrik D'haeseleer, and Michael Thelen investigated the molecular mechanisms of the bacterium's ionic liquid tolerance using a combination of phenotypic growth assays, phospholipid fatty acid analysis, and RNA sequencing. The figure is a whole-genome metabolic reconstruction of SCF1 showing differentially expressed pathways and transporters.



TEAM WINS BEST POSTER AWARD AT MRS MEETING

Members of Livermore's Additive Fabrication Projection Microstereolithography Team—which has been funded by the LDRD Program—won a Best Poster Award at the 2012 Materials Research Society (MRS) Spring Meeting and Exhibit, **held** at the Moscone Center in San Francisco. The poster, *Fast, Flexible, Additive Fabrication of Complex Three-Dimensional Structures with Microscale Architectures using Projection Microstereolithography*, received the award for excellence in material science research. LLNL coauthors were Xiaoyu (Rayne) Zheng (pictured), Joshua Deotte, Todd Weisgraber, George Farquar, and Chris Spadaccini. Collaborating coauthors were from MIT and the University of Illinois at Urbana-Champaign.



TECH LICENSED FOR MEDICAL, ENVIRONMENTAL, ENERGY, AND FOOD SAFETY APPLICATIONS

The Laboratory has licensed its micropower ultra-wideband impulse radar technology to PneumoSonics, Inc., a wholly owned subsidiary of ElectroSonics Medical, to use in pneumothorax detectors. PneumoSonics has earned a CE mark for sales in Europe and is seeking FDA approval for U.S. sales.

Licensed to Field Forensics, Inc., is Livermore's micro-thin-layer chromatography and technology for the separation and identification of explosives. Largo, Florida-based Field Forensics, already a multiple licensee, manufactures disposable kits for explosives screening and forensic evidence collection devices and plans to use the technology not only for identifying explosives but also explosive precursors, illicit drugs, and illicit drug precursors.

EmiSense Technologies, LLC, has licensed an LLNL nitrogen oxide (NO_x) and hydrocarbon sensor technology. The California-based company has a cooperative research and development agreement with LLNL to produce a manufacturable NO_x sensor technology that meets automotive performance and cost criteria to be suitable for commercialization by an automotive supplier.

Siemens Energy, Inc., one of the world's leading suppliers of components and systems to the energy industry, licensed Laboratory software developed under a cooperative research and development agreement that the company had with Livermore from 2008 to 2011. The software is designed to increase the cost effectiveness of wind farms by forecasting local winds more accurately than was previously possible.

In April, Livermore licensed to Luminex Corporation patents related to the detection of salmonella for epidemiological testing, veterinarian and production animal testing, environmental testing, and food production and food safety testing. Luminex Corporation, founded in 1995, is a biotechnology company based in Austin, Texas. Luminex develops, manufactures, and markets proprietary biological testing technologies with applications throughout the life-sciences industry.

POSTDOC WINS EPS PLASMA PHYSICS PH.D. RESEARCH AWARD

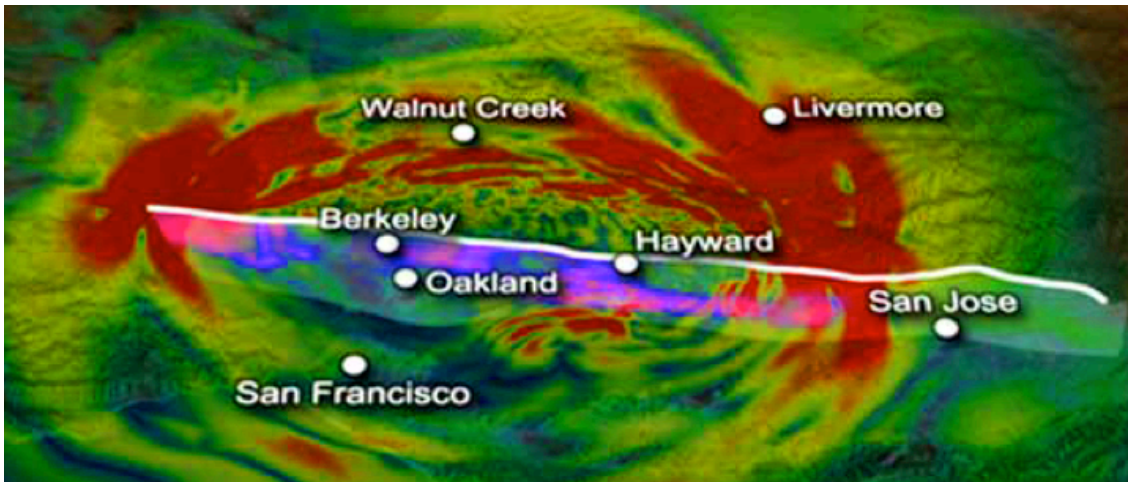
Frédéric Pérez, a PLS postdoc working on fast ignition, is one of three recipients of this year's Ph.D. Research Award from the Plasma Physics Division of the European Physical Society (EPS). The EPS prize is given in recognition of exceptional quality work carried out by a young scientist. Frédéric's award is for his doctoral thesis, *Study of Supra-Thermal Electron Transport in Solid or Compressed Matter for the Fast-Ignitor Scheme*. His results showed that in some experimental conditions, fast electrons can be collimated due to self-generated magnetic fields produced by resistivity gradients, which may have important implications for the fast ignition approach to inertial-confinement fusion. The award will be formally presented at the 39th EPS plasma physics conference, which begins in Stockholm, Sweden, on July 2.

LAB TECHNOLOGY SHOWCASED AT CLEO

The Industrial Partnerships Office showed off Laboratory technologies available for licensing at the 2012 Conference on Lasers and Electro-Optics (CLEO) in San Jose. CLEO serves as the premier international forum for scientific and technical optics, uniting the fields of lasers and electro-optics by bringing together all aspects of laser technology, from basic research to industry applications. At this year's conference, the theme of which was technology transfer, more than 300 participating companies showcased their latest products and applications. The program provided a forum for entrepreneurs and researchers from startups, major universities, large businesses, and national laboratories to present exciting new technologies that are ready and available for commercialization. LLNL highlighted its technologies in laser optics polishing, strontium iodide, transparent ceramics, and plastic scintillators.

LAB SEISMIC WORK FEATURED AT ACADEMY OF SCIENCES

The Laboratory's work in computational seismology is featured in the exhibit "**Earthquake**" at the California Academy of Sciences. The show opened May 26 and combines a full-dome show at the Morrison Planetarium with an accompanying museum exhibit. The LLNL content includes simulations of ground motions in the magnitude-7.9 1906 San Francisco earthquake and a simulation of a possible magnitude-7.05 Hayward Fault earthquake (shown in the figure), both made using the code WPP.



GENERAL ELECTRIC TO USE LLNL COMPUTING TO IMPROVE FUEL INJECTORS FOR AIRCRAFT

GE Global Research announced its **participation** with LLNL in an effort to design more powerful and efficient aircraft engines using computer simulation. GE will partner with researchers from Arizona State University and Cornell University to study the unsteady spray phenomena thought to be ideal for fuel injectors. Through large-eddy simulation, GE hopes to discover an ideal spray pattern and fuel injector design and thereby reduce the iterations of lengthy, expensive real-world optimization trials. Although the research is initially aimed at aircraft engines, the knowledge gained from these experiments may work its way into other products, such as locomotive engines and land-based gas turbines.

SEISMOLOGIST INTERVIEWED FOR SEQUESTRATION STORY

Livermore seismologist Bill Foxall was **interviewed** for an article in *Greenhouse Gas Reduction Technologies Monitor* on the risk of induced seismicity in large-scale CO₂ storage projects. Bill states that risk assessment and site characterization and monitoring can minimize the risk of seismic events. "In many cases," he is quoted as saying, "it won't be a major issue as long as [developers] plan their operations accordingly."

CARBON CAPTURE EXPERT ON PBS

Livermore's Julio Freidman was **interviewed** by PBS News Hour for his expert viewpoint on a technology for post-combustion carbon capture being used in China. Julio cites

this example as demonstrating that carbon capture is practicable and that costs and performance are now fairly well understood.

LAB TEAMS WITH BAY AREA COMPANIES TO FIGHT CYBER CRIME

As **reported** recently by the *Mercury News*, several Bay Area-based technology companies are partnering with Livermore's **Network Security Innovation Center** to exchange "threat information and best practices and relay their collective insight to federal agencies," the ultimate goal being not only to bolster the nation's defenses against cyber warfare but also to protect the intellectual property of U.S. companies.

QUANTUM SIMULATIONS OF RADIATION DAMAGE ON COVER OF *PHYSICAL REVIEW LETTERS*

In a [paper](#) published in *Physical Review Letters*, Alfredo Correa (PLS) and colleagues used time-dependent density functional theory to investigate the effects of non-adiabaticity on the early stages of radiation-damage cascades. They calculated the electronic excitations produced in aluminum metal subjected to bombardment by energetic protons and modeled what happens to the nuclei of the target material when their electrons are excited by the passage of a fast-moving particle. The team found that in the non-adiabatic case, the effect of electronic excitations on the interatomic forces in the aluminum differs substantially from the adiabatic case, demonstrating an important connection between electronic and nuclear stopping that is missing in the Born-Oppenheimer

approximation. These results reveal new phenomena that occur in the early stages of radiation damage. A full understanding of the processes involved would allow us to manipulate them to our advantage, not only in materials used in nuclear applications, but also for materials relevant to the aerospace industry and for assessing the effects of radiation on biological tissues.

ULTRAFAST TRANSITION IN GRAPHITE

In a groundbreaking experiment for plasma physics and ultrafast materials science, LLNL physicist Stefan Hau-Riege and colleagues used the x-ray free-electron laser (XFEL) at the Stanford Linear Accelerator Center to heat graphite to induce a transition from solid to liquid and to a warm, dense plasma in about 40 femtoseconds. This marks the first time that an x-ray-irradiated material has been observed to transition to two different states of matter this quickly.

By using pulses of different lengths and looking at the differences in the resulting spectra, the team was able to extract the time dependence of important plasma parameters, such as electron and ion temperatures and ionization states. One important and surprising finding was that the x-ray fluence needed to disrupt the lattice structure of graphite, and thus degrade the Bragg-peak diffraction data for that lattice, is smaller, and the ion-heating rate faster, than is predicted by current models for x-ray-matter interactions. Because the rate of energy transfer from the x-ray pulse to the sample is so fast, it may be substantially more difficult than anticipated to achieve one of the “holy grail” applications of XFELs—to obtain diffraction patterns from single biomolecules. The research was [published](#) in *Physical Review Letters*. LLNL’s participation in this work was supported by the LDRD Program.



NIF ACHIEVEMENTS ON COVER OF PLASMA JOURNAL

A **paper** reporting the results of the initial implosion experiments on NIF in late 2010 and early last year was featured on the cover of the April issue of *Plasma Physics and Controlled Fusion*. (The cover photograph is of a cryogenic ignition target before being fully enclosed by the shroud.) Achieving ignition and thermonuclear burn via indirect-drive inertial confinement fusion on NIF rests on managing four general parameters: implosion symmetry, timing of the laser shocks, implosion velocity, and hydrodynamic mix, that is, the amount of ablator

(fuel capsule) material mixing with the deuterium-tritium (DT) fuel because of hydrodynamic instability. In the initial experiments, the DT fuel was diluted with hydrogen and contained just a small amount of deuterium to limit the neutron yield, allowing sensitive diagnostics to be mounted in close proximity to the target. These experiments showed continuing improvement for achieving fusion and provided implosion performance data on hotspot formation and nuclear fuel assembly needed for determining progress towards ignition. Lead author Siegfried Glenzer was joined on the paper by a large group of collaborators from the National Ignition Campaign, MIT, and the U.K. Atomic Weapons Establishment.

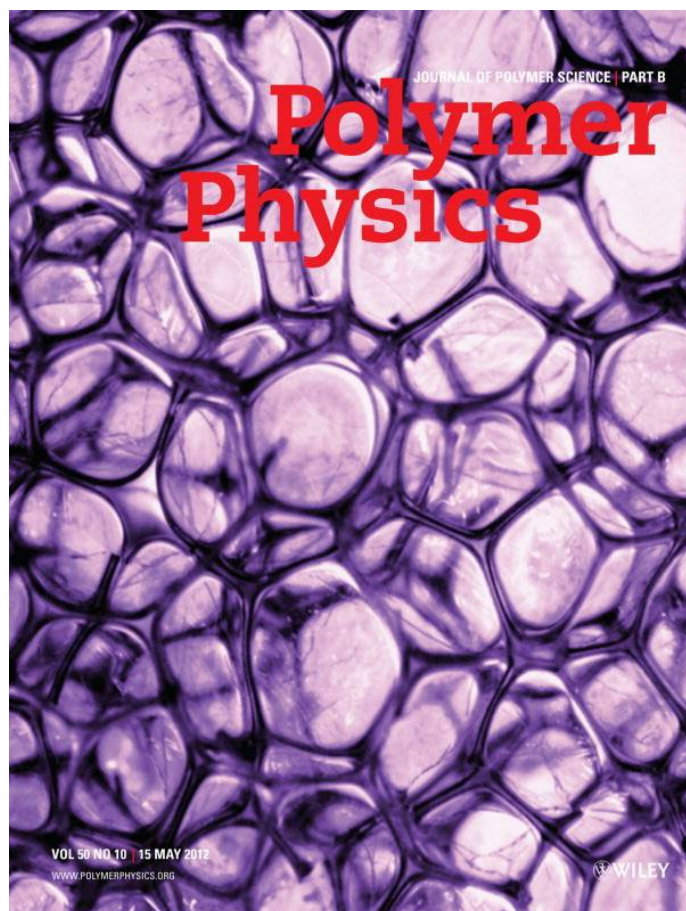


BONE RESEARCH PAPER SELECTED FOR INCLUSION IN THE FACULTY OF 1000 DATABASE

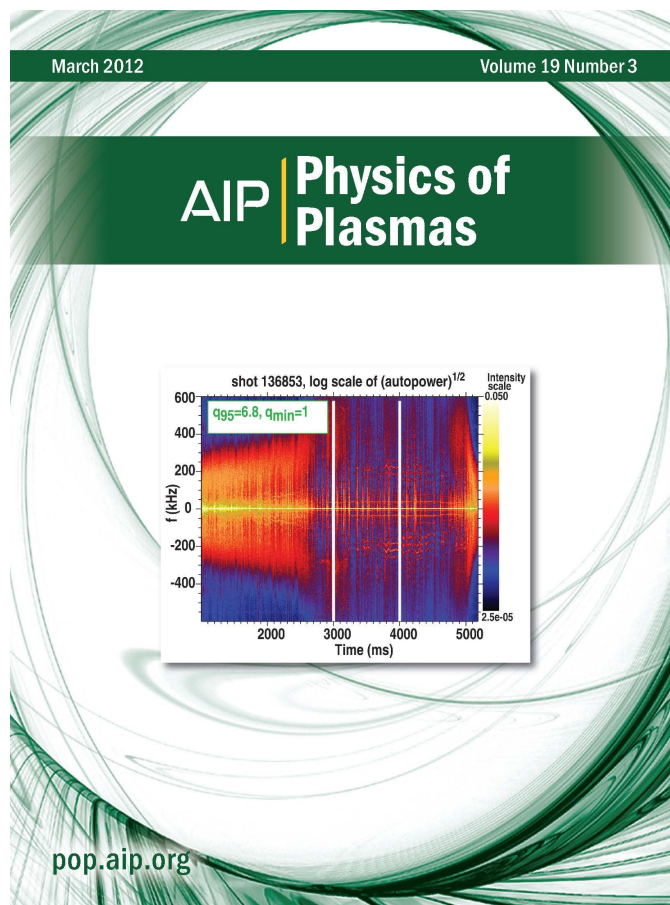
A **recent paper** coauthored by Nicole Collette and Gaby Loots has been selected for inclusion in the Faculty of 1000 (**F1000**) database, which collects the top 2% of published articles in biology and medicine. The paper was given a F1000 evaluation score of 10, the highest possible score, signifying a paper of exceptional significance. Coauthored with colleagues from UC Merced, the paper reports that mice lacking the gene for the bone-production-inhibiting protein sclerostin show a depletion of B cells in their bone marrow. Sclerostin interrupts the pathway for bone synthesis and plays an important regulatory role in normal bone metabolism. A lack of sclerostin, or the presence of antibodies that bind to it, leads to enhanced bone growth, which has made sclerostin an important target for drugs treating osteoporosis. However, this paper's findings suggest negative side effects on the immune system in patients treated with sclerostin inhibitors, and also suggest that osteocytes, which produce sclerostin, play a heretofore unrecognized role in B cell production and survival.

ULTRALOW-DENSITY POLYMER WORK ON COVER OF *JOURNAL OF POLYMER SCIENCE*

The cover of the May 15 issue of *Journal of Polymer Science Part B—Polymer Physics* features an image from a [paper](#) authored by Lawrence scholar Pooja Singhal, Ward Small, and Thomas S. Wilson, with colleagues from Texas A&M University and UC Davis. The paper reports on the synthesis of polyurethane shape-memory polymer foams using a combination of physical and chemical blowing processes. The resulting foams have a uniform cell structure and densities as low as 0.015 g/cm^3 . A dense, covalently crosslinked structure gives these materials a high modulus, resulting in strong shape recovery (97–98%) and a high volume expansion factor—up to 70 compared to its fully compressed state. In vitro biocompatibility tests suggest they may have potential use in biomedical applications.



TOKAMAK RESEARCH ON COVER OF *PHYSICS OF PLASMAS*



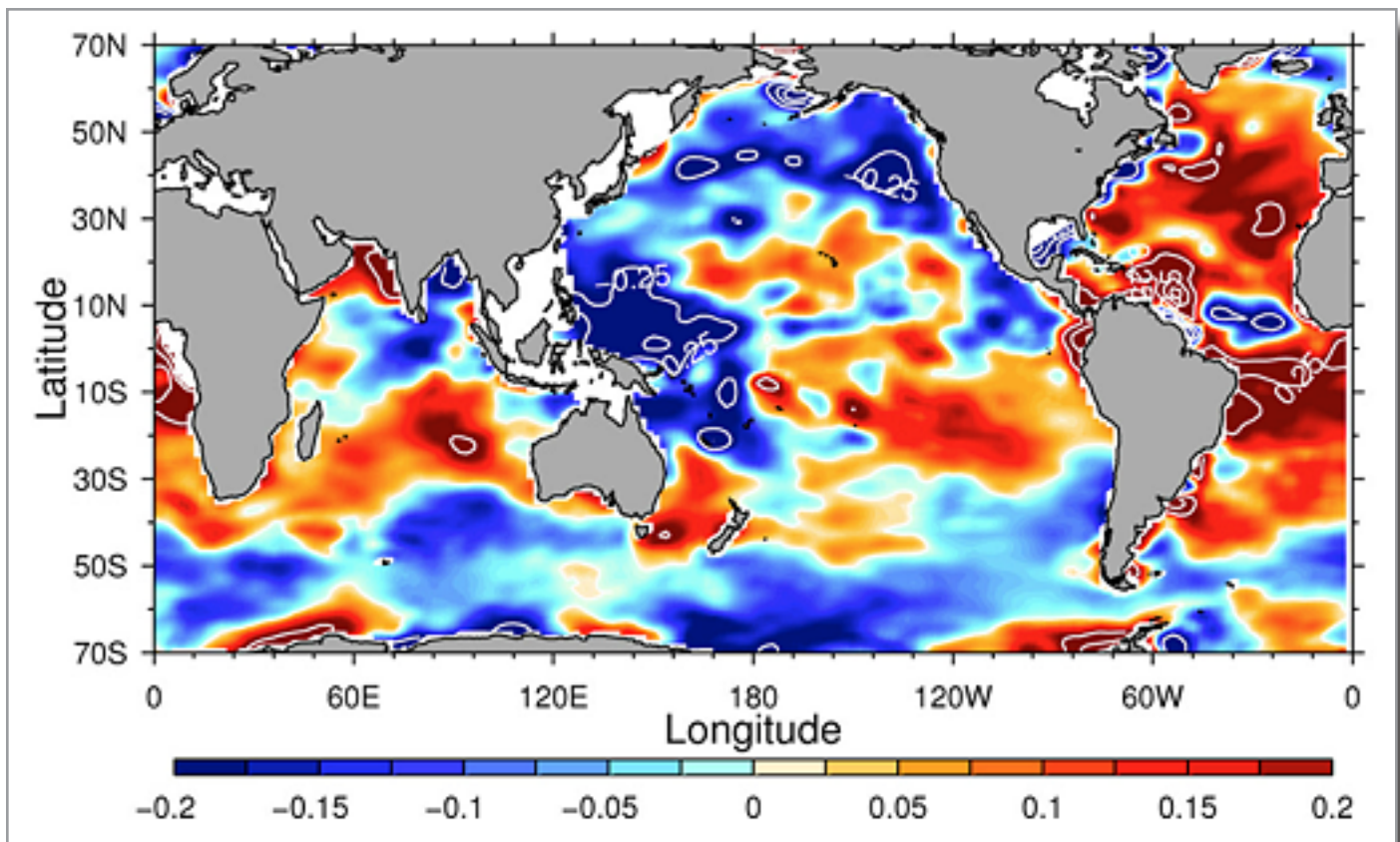
The cover of *Physics of Plasmas* features a figure from a [paper](#) by Christopher Holcomb and colleagues from General Atomics, ORNL, UCLA, and the University of Wisconsin on how the thermal transport properties of a confined plasma vary as a function of the plasma safety factor, q . Taking its name from the fact that larger values of q are associated with operating conditions that reduce the risk of undesirable current-driven plasma instabilities, the plasma safety factor is an important parameter in magnetic confinement geometries, specifically the number of times a magnetic field line goes around a torus the “long way” (toroidally) for each time around the “short way” (poloidally). The paper discusses the observed transport properties of nine steady-state scenarios based on recent experiments at the DIII-D tokamak. Electron and ion thermal transport were observed to have very different depen-

dencies on the safety factor profile. Furthermore, the observed thermal diffusivity trends as a function of q profile are not consistent with predictions from current models, indicating some physics are still missing in the models.

POSTDOC'S SCIENCE PAPER: OCEAN SALINITY HINTS OF CLIMATE DISRUPTION

In a [paper](#) published in *Science*, LLNL postdoc Paul Durack, with coauthors from Australia's Commonwealth Scientific and Industrial Research Organisation, provide clear evidence for changes in the salinity of the world's oceans over the past 50 years. Fundamental thermodynamics and climate models suggest that dry regions will become drier and wet regions will become wetter in response to global warming, but efforts to detect this long-term response

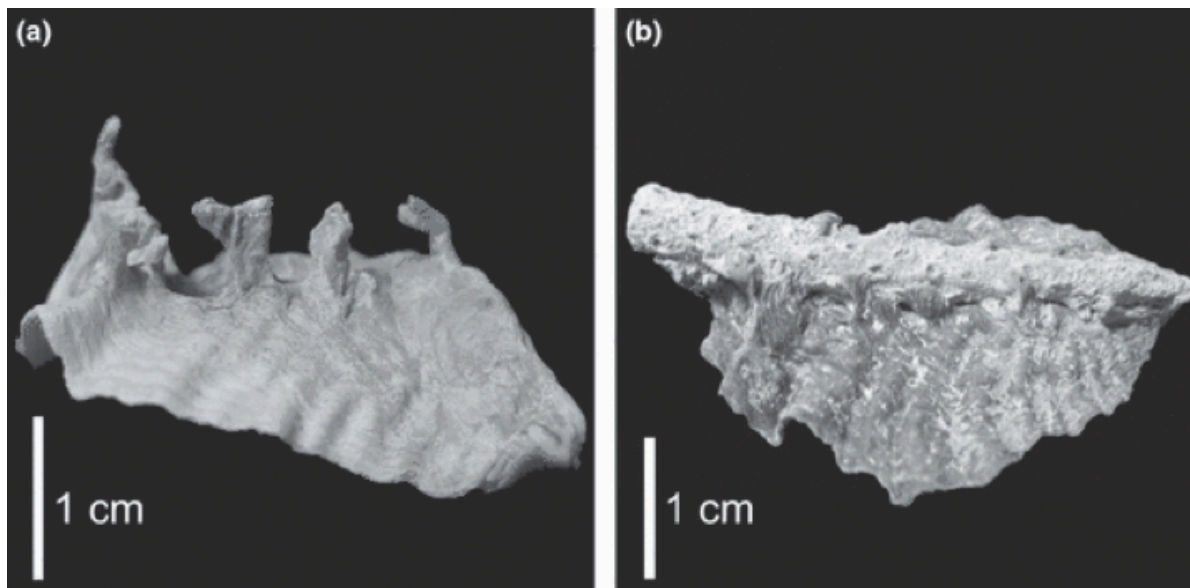
in the sparse dataset of observed surface rainfall and evaporation have been inconclusive, hence the authors' focus on ocean salinity. The authors attribute the salinity changes to shifts and acceleration in the global rainfall and evaporation cycle (the "hydrologic cycle") tied directly to climate change. The team compared observed ocean salinity changes with the relationships between salinity, rainfall, and evaporation predicted by climate models, finding that ocean salinity patterns have an identifiable fingerprint of an intensifying global hydrologic cycle and that the cycle is intensifying at a rate of $8\% \pm 5\%$ per degree of surface warming. This rate is twice the response projected by current-generation climate models and suggests that a substantial (16–24%) intensification of the global water cycle will occur in a future two to three degrees warmer. Although not the first to report such findings, "the paper appears to marshal more scientific evidence than any paper to date in support of a high estimate," as the *New York Times* [reported](#).



CARIBBEAN CORAL DECLINE PREDATES CLIMATE CHANGE

Center for Accelerator Mass Spectrometry scientist Tom Guilderson coauthored a [paper](#) in *Ecology Letters* showing that declines in the health of Caribbean coral reefs predate the effects of climate change. The authors used enhanced sampling techniques and accelerator mass-spectrometry radiocarbon dating to

deposition of silt, nutrients, and pollution onto coral reefs from land clearing and the depletion of reef fish that prevent algae from overtaking reefs. The figure shows the attachment structures of the oyster species (*Dendostrea frons*) previously dominant at the site examined: (a) hooks attaching to a branching gorgonian and (b) a specimen attached to branching staghorn coral. Prior to 1960, *D. frons* declined from 40% to 18% at lagoon sites.

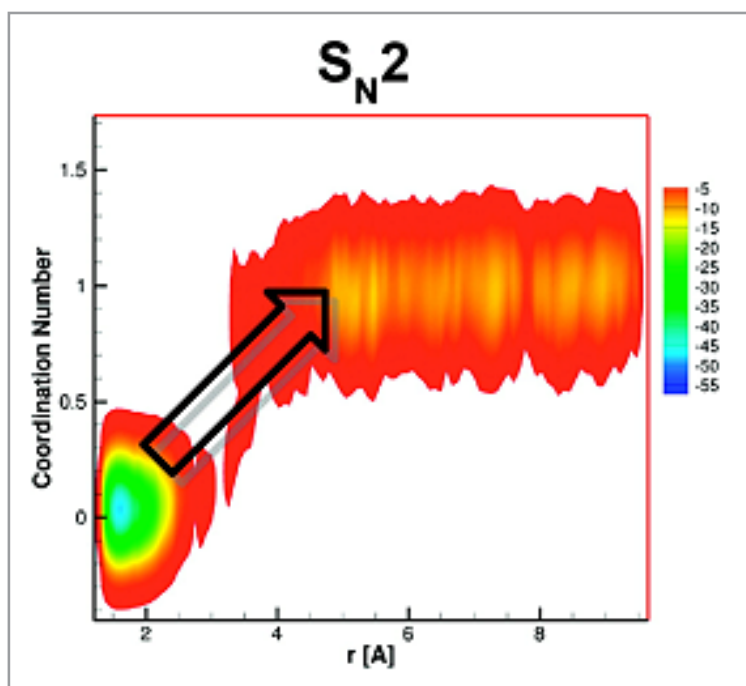


reconstruct the timeline of the historical change in coral reefs located on the Caribbean side of Panama, going back as far as the 1800s. To reconstruct this timeline, the team took samples layer by layer underneath modern reefs and determined the radiocarbon ages of coral skeletons in each layer. For each layer, they examined the assemblage of fossils present and were able to link fluctuations in the types and numbers of coral and mollusks over time to historical records of land clearing. The number of different species in each layer is a measure of the ecological health of the reef, and changes in the diversity over time provide an indication of the changing overall health of the reef. They determined that damage to coral reefs from land clearing and overfishing predates by decades damage caused by anthropogenic climate change. This study is the first to quantify the changes that reef corals and mollusks have undergone as a result of the long-term stress caused by the

NEW GAMMA-MEASURING METHOD

A team led by LLNL and South African colleagues has developed a new experimental method to measure the photon strength function (PSF)—key to understanding gamma-ray emissions—at the lower energies relevant to the environments in which nucleosynthesis occurs, such as stellar interiors and supernovae. Knowing the full energy and multipolarity dependence of the PSF is also central to models of fuels in fission reactors. Working at the 88-Inch Cyclotron at LBNL, the team confirmed an increase in PSF for low-energy photons, resolving a decade-long scientific debate. These results emphasize the need for further experiments at NIF to investigate these important nuclear reactions. This work was [published](#) in *Physical Review Letters*. Livermore's participation in this research was funded by the LDRD program.

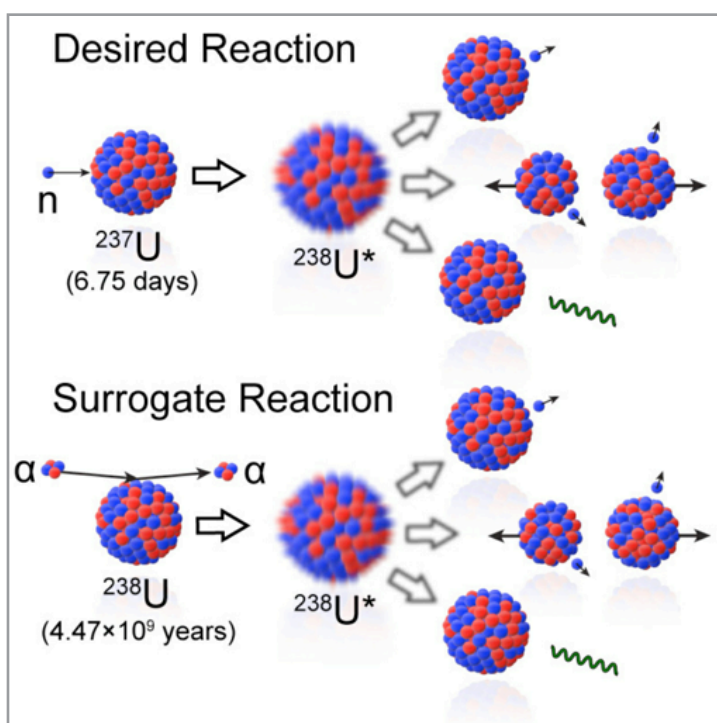
HOW SURFACES CATALYZE NERVE AGENT DEGRADATION



Using first-principle molecular dynamics simulations based on density functional theory, PLS researchers I-Feng Kuo, Christian Grant, Richard Gee, Sarah Chinn, and Adam Love (now at Johnson Wright, Inc.) **investigated** potential degradation pathways for sarin in the presence of both hydrophilic and hydrophobic surfaces. They found that when sarin is within hydrogen-bonding distance of a hydrophilic surface, the most probable degradation pathway was the S_N2 mechanism, in which the molecule is hydrolyzed and hydrofluoric acid is produced. This is the same reaction mechanism that occurs in bulk solution, but the presence of the surface lowers the energy barrier for the reaction, increasing the degradation rate. For hydrophobic surfaces, they found that degradation proceeds via an S_N1 -type mechanism in which sarin's phosphorus-fluorine bond breaks first, followed by a second step in which water acts as a nucleophile. Thus hydrophilic surfaces have a catalytic effect on sarin degradation. The figure shows the free-energy surface for sarin degradation near a hydrophobic surface, with an energy scale of kcal/mol and the arrow showing progression from reactant to product state.

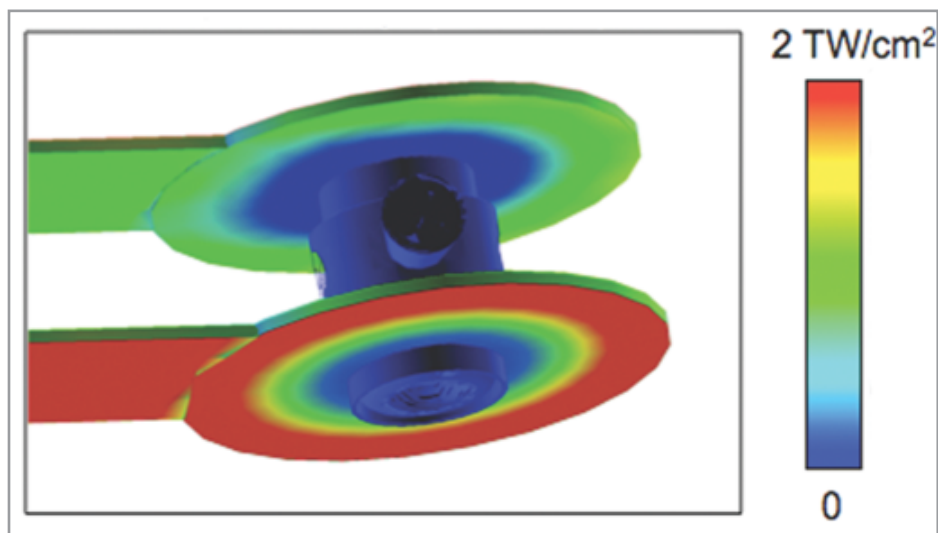
SURROGATE NUCLEAR REACTIONS APPROACH FEATURED IN *REVIEWS OF MODERN PHYSICS*

In an **invited paper** in *Reviews of Modern Physics*, LLNL scientists Jutta Escher, Jason Burke, and colleagues review the use of the “surrogate nuclear reactions” approach for cross section determination. This capability is the culmination of a decade of experimental and theoretical effort by many researchers at LLNL to refine and extend this approach and has generated worldwide interest in the technique, as well as strong collaborations between the LLNL researchers and nuclear scientists at many institutions (seven national laboratories and six universities in five countries). The method is expected to become an important focus of inverse kinematics experiments at rare-isotope facilities such as the DOE's Facility for Rare Isotope Beams at Michigan State University, a new national user facility for nuclear science. The figure shows the basic idea of the surrogate approach—to replace the first step of the desired reaction with an alternative (surrogate) reaction that is experimentally easier to access yet populates the same compound nucleus.



“KEYHOLE” FUSION EXPERIMENT LEADS TO IMPROVED TARGET DESIGN

Early results of the National Ignition Campaign (NIC) shock timing “keyhole” target experiments to assess and minimize the adiabat (entropy) in deuterium–tritium implosions were reported in a *Physics of Plasmas* [article](#). The article describes the “keyhole” target geometry—a modified ignition hohlraum with a diagnostic cone for direct measurement of shock waves entering the liquid-deuterium-filled capsule. In these NIF experiments, shock timing was found to be higher than required for successful ignition, with an inferred implosion adiabat as high as 7.3, compared



to that required for ignition (1.47). Considerable shot-to-shot variation was found to result from air-ice condensation on the laser entrance hole windows, reducing the strength of the first laser shock. This observation has led to a target modification—the laser entrance hole “storm window”—that is now used in all cryogenic NIC targets and that has significantly improved shot-to-shot variation and agreement with post-shot simulations. Lead author Harry Robey was joined by collaborators from LLNL, the Laboratory for Laser Energetics at the University of Rochester, Sandia National Laboratory, and General Atomics in San Diego. The figure shows a 3-D model of the spatial laser intensity distribution on the hohlraum and unconverted light shields.

STUDY COMPARES NATURAL SOIL CARBON SEQUESTRATION IN DIFFERENT SETTINGS

Forest soils represent a significant pool for carbon sequestration and storage, but the factors controlling soil carbon cycling are not well constrained. In a [paper](#) published in *Biogeochemistry*, researchers Karis McFarlane and Tom Guilderson and colleagues from LBNL, ORNL, and the USDA compare the soil carbon storage and dynamics in five broadleaf forests in the Eastern U.S. that vary in climate, soil type, and soil ecology. Total soil-carbon inventory in the top 60 cm of soil were lowest at the site with the coarsest soil texture and at the warmest site. Differences in

climate only partly explained differences in the soil organic matter content and mean turnover times, which also spanned a large range of 75–480 years.

The turnover rates, inferred from ^{14}C measurements made at Livermore’s Center for Accelerator Mass Spectrometry, were fastest at the warmest site but slowest at sites in the northeast, rather than the coldest sites in the upper Midwest. The team speculates that soil texture, mineralogy, drainage, and biological activity may be at least as important as climate for controlling

the soil carbon dynamics in temperate broadleaf forests. Studies of this type are essential to understanding how the carbon sequestered in soils will respond to changes in climate, and how those changes should be incorporated into coupled ecosystem–atmosphere models used to predict the behavior of the Earth’s climate. This work received support from Livermore’s LDRD Program.

ADIABATIC INDEX OF SHOCK-COMPRESSED BERYLLIUM

Beryllium is a candidate capsule ablator material for inertial confinement fusion experiments, mak-

ing knowledge of its thermodynamic and transport properties at extreme density, pressure, and temperature of high interest for National Ignition Campaign experiments. A **report** by LLNL researchers and their collaborators on the first direct measurement of the adiabatic index (heat capacity ratio) through x-ray Thomson scattering from shock-compressed beryllium was published in *Physical Review Letters*. The paper describes a novel experimental technique in which x-ray photons probe the bulk properties of matter during the collision of two counterpropagating shocks and states that beryllium has great potential not only for fusion research but also material research and laboratory astrophysics. The figure shows the target containing the 250- μm beryllium foil that

was radiated from both sides by a total of 12 laser beams operating at a wavelength of 351 nm.

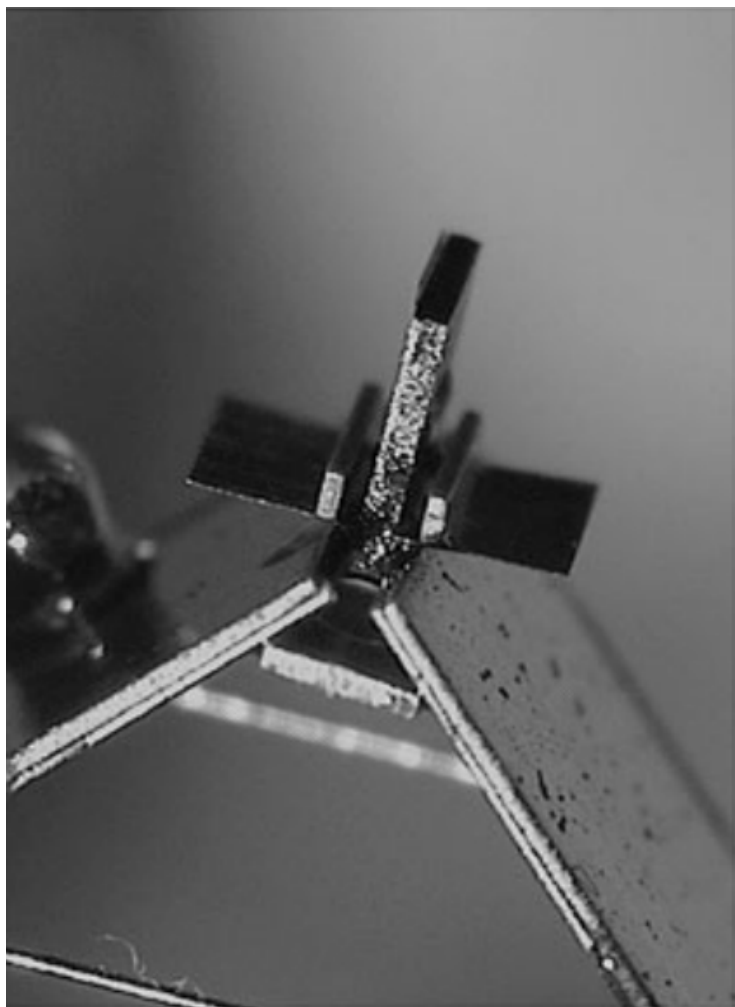
CLOUD EFFECTS STILL MAJOR UNCERTAINTY IN CLIMATE MODELS

In anticipation of the 2013 publication of the Intergovernmental Panel on Climate Change's fifth assessment report, the climate-modeling community has been collaborating on the Fifth Coupled Model Intercomparison Project (CMIP5), an international effort to identify research directions and specify standardized parameters under which atmosphere-ocean coupled general circulation models should be tested to enable comparison on an equal footing. Livermore atmospheric scientist Karl Taylor and colleagues from the U.K.'s Hadley Centre and the University of Reading **have published** the first analysis of the predicted equilibrium climate sensitivity—the long-term change in global average surface air temperature that would result from a permanent doubling of atmospheric CO_2 concentrations—of the 15 models that make up CMIP5. They found that today's models predict a climate sensitivity of 2.1–4.7°C, close to the 2.1–4.4°C range predicted by the previous generation of models. As with previous multimodel comparisons, Karl et al. found that model assumptions about the interactions between shortwave radiation and clouds are the largest remaining sources of uncertainty. This paper is **featured** as a Editor's Highlight in *Geophysical Research Letters*.

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Questions? Comments?

Please contact Paul Kotta at kotta1@llnl.gov or (925) 424-4018.